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Light propagation with nonminimal couplings in a two-component cosmic dark fluid with an Archimedean-type force, and unlighted cosmological epochs

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Abstract

During the evolution of the universe there are at least two epochs during which electromagnetic waves cannot scan the universe's internal structure to bring information to outside observers. The first epoch is when photons are in local thermodynamic equilibrium with other particles, and the second is when photon scattering by charged particles is strong. One can call these two periods of cosmological time as standard unlighted epochs. After the last scattering surface, photons become relic photons and turn into a source of information about the universe. Unlighted cosmic epochs can also appear when one considers nonminimal theories, i.e., theories in which the electromagnetic field is coupled in an intricate way with the cosmological gravitational field. By considering a cosmological model where the dark sector, i.e., the dark energy and dark matter, self-interacts via an Archimedean-type force, and taking into account a nonminimal coupling theory for the electromagnetic field, we discuss the appearance of unlighted epochs. In the framework of our nonminimal theory, a three-parameter nonminimal Einstein-Maxwell model, the curvature coupling can be formulated in terms of an effective refraction index n(t). Then, taking advantage of a well-known classical analogy, namely, in a medium with n2<0 electromagnetic waves do not propagate and their group velocity, i.e., energy transfer velocity, has zero value at the boundary of the corresponding zone, one can search for the unlighted epochs arising in the interacting dark fluid cosmological model. We study here, both analytically and numerically, cosmological models admitting unlighted epochs.

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